Codes and Standards Research Report

California's Residential Indoor Water Use

March 2014 Update

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California Homebuilding Foundation®
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The California Homebuilding Foundation invests in the future of homebuilding through: Endowments that provide scholarships and fund industry research; publishing current construction and new home statistics; presenting training seminars; and supporting high school courses that encourage young people to choose careers in the industry. The Foundation also hosts California's top industry award, Hall of Fame.

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ConSol has been providing energy solutions for builders, government agencies, utilities, trade associations and developers since 1983. ConSol services include: energy efficiency, retrofit, and green program design and management; building audits; builder energy code training; and consulting services for the residential and commercial building industry. ConSol offers leading-edge research and energy consulting in systems, technologies and codes to improve sustainability of new and existing residential and commercial buildings and developments. ConSol is dedicated to helping our clients in the Western U.S. provide resource-efficient homes and buildings that are efficient, affordable and sustainable.

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Executive Summary

California has made great progress in reducing internal water use in newly constructed homes through the implementation of the California Green Building Standards Code (CALGreen) and updated plumbing fixture standards. New three-bedroom, single-family homes with four occupants in California use an estimated 46,500 gallons of water per year for internal use. This represents a savings of over 29,000 gallons of water per year from homes built in 2005 and 46,000 gallons of water per year from homes built in 1980.

Given the implementation of CALGreen's mandatory water conservation measures for new homes over the past 4 years, existing homes now represent a much greater savings potential than newly constructed homes in California. More than half of California's 7,500,000 existing single-family homes were constructed before 1980 and are equipped with old fixtures, which can use up to three times more water than current available models. If existing homes were required to comply with 2013 CALGreen, it would save an equivalent of 8.7% of California's reservoir capacity (over 300 billion gallons annually).

The most cost-effective water savings actions for existing homes are retrofitting the older model homes with showerheads that only allow the release of 2.0 gallons of water per minute and low-flow toilets that only use 1.28 gallons of water per flush.

California Indoor Water Use

The 2010 CALGreen Code[1] set new standards for the maximum flow rates of plumbing fixtures in new construction. Taking effect on January 1, 2011, this collection of construction requirements has resulted in the most significant reduction in indoor water use in the history of California building codes. The 2010 CALGreen Code called for a 20% reduction in indoor water use. CALGreen included guidance on how to calculate the "baseline" indoor water use for a current new single-family home. As an alternative to the 20% reduction performance standard, a builder could choose to use plumbing fixtures that comply with a prescriptive list of maximum water flow rates.

Table 1 lists the historical fixture flow rates and appliance standards required by code from 1975 to 2013. Nationally, water use codes have been very slow to change. In 1980, the national Energy Policy Act lowered the showerhead flow rates to 2.5 gallons per minute (gpm) and toilet flow rates to 3.6 gallons per flush (gpf). Before 1980, those values were typically 3.5 gpm and 5.0 gpf, respectively.

Fixture and Appliance Standards Over Time						
	1975	1980	1992	2009	2011	2013
Shower (gpm)	3.5	2.5	2.5	2.5	2.0	2.0
Toilets (gpf)	5.0	3.6	1.6	1.6	1.28	1.28
Faucets (gpm)	2.5	2.5	2.5	2.2	1.8	1.8/1.5
Clothes Washers (gal/cubic foot)	15.0	15.0	15.0	8.5	6.0	6.0

Table 1: Flow Rates of Fixtures over Time

The recent changes to the 2010 and 2013 CALGreen low-flow faucets and showerheads did not add significant costs to the home. The cost increase for low-flow showerheads fixtures is less than $15 per fixture; however, most builders were already using the faucets. The low-flow (1.28 gpf) toilet requirement has added approximately a $75 incremental cost per toilet.

The updated 2013 edition of CALGreen Code eliminated the 20% water reduction "performance option," leaving only the prescriptive list of maximum water flow rates for each of the indoor plumbing fixtures. This simplification has made enforcement much easier; however, it has resulted in a minimal decrease in water use compared to the initial 2010 CALGreen Code.

CALGreen only covers indoor water use from showers, faucets, and toilets. The code does not provide guidance for clothes-washing machines, which account for 4% of total annual water use. On average, a top-loading washing machine uses between 40 and 45 gallons per wash.[2] A horizontal axis washer can use between 15 and 30 gallons. Appliance standards effective in California before 2010 limited the

[1] http://www.bsc.ca.gov/Home/CALGreen.aspx

[2] http://www.allianceforwaterefficiency.org/Residential_Clothes_Washer_Introduction.aspx

amount of water a washing machine could use to 8.5 gallons per cubic foot of capacity. In 2010, this number was dropped to 6 gallons per cubic foot. The average capacity for a clothes-washing machine is 3 cubic feet, meaning a new washing machine averages 18 gallons per wash. Studies have shown that the average household does between 300 and 400 loads of laundry per year.[3] To determine the current estimated indoor water use, Table 2 combines the CALGreen fixture and use assumptions with the washing machine usage to determine the estimated indoor water use for a new three-bedroom home. The total indoor water use for a new home with four occupants is approximately 46,500 gallons per year.

Total Indoor Water Use, New Three Bedroom Home					
Fixture Type	**Flow Rate (gpm or gpf)**	**Duration (mins.)**	**Daily Uses**	**# of Occupants**	**Gallons/Year**
Showerheads	2.0	8	1	4	23,360
Lavatory Faucets	1.5	0.25	3	4	1,643
Kitchen Faucets	1.8	4	1	4	10,512
Toilets	1.28	---	3	4	5,606
Fixture Water Use					41,121
	Loads per Year		Gallons per Load		
Clothes Washers	300		18		5,400
Total Indoor Water Use, New Three Bedroom Home					**46,521**

Table 2: Indoor Water Use for a New Three Bedroom Home

While there is limited water savings potential in new California homes, existing California homes represent a clear and significant conservation opportunity. Old toilets and showerheads can use up to three times more water than current required fixtures. The historical indoor water use of homes built to national and State codes is listed in Table 3 in gallons and percent reduction.

	1975	1990	2009	2011	2013
Shower	40,880	29,200	29,200	23,360	23,360
Toilets	21,900	15,768	7,008	5,606	5,606
Kitchen and Lavatory Faucets	17,338	17,338	15,257	12,483	12,155
Clothes Washer	12,000	12,000	7,650	5,400	5,400
Total Indoor Water Use	92,118	74,306	59,115	46,849	46,521
Reduction		19%	20%	21%	1%

Table 3: Annual Indoor Water Use over Time

Indoor water fixtures have significantly changed over the last forty years. As shown in Figure 1, there has been a 50% reduction in indoor water use due to the incorporation of low-flow fixtures and

[3] http://www.consumerenergycenter.org/residential/appliances/washers.html,

appliance requirements for new homes. Approximately 70% of this reduction comes from the installation of low-flow showerheads and low-flow toilets. Washing machines contribute an additional 17% of this reduction with faucets contributing the remaining 12%.

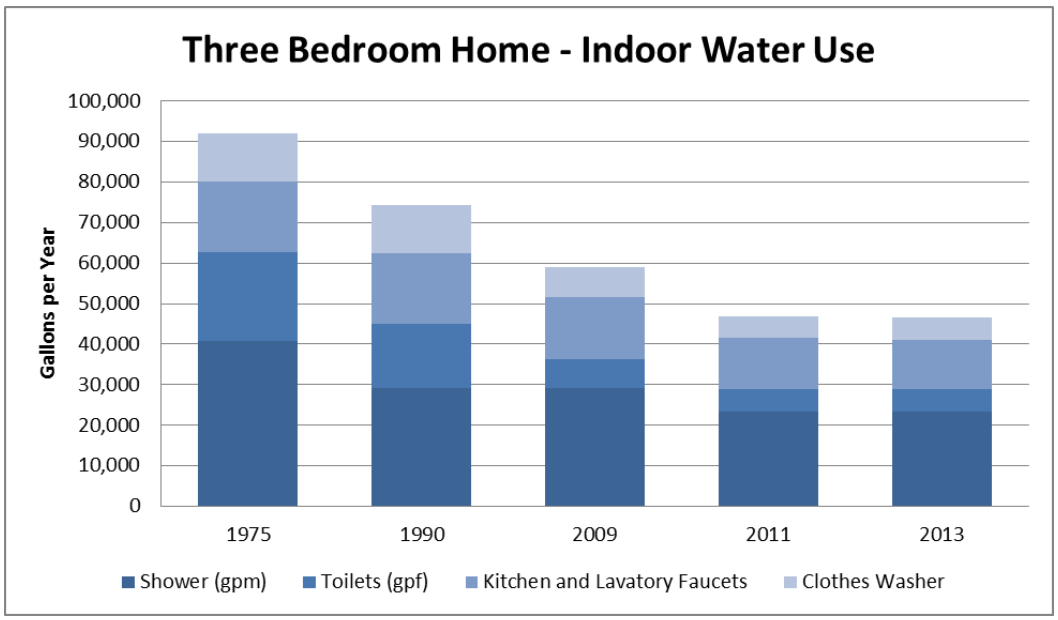

Figure 1: Indoor Water Use over Time

There were over 7,500,000 single family homes in existence prior to CALGreen being implemented on January 1, 2011. Addressing existing housing, particularly old showerheads and toilets, can be a very cost-effective way of reducing water use. In order to achieve deep reductions in the amount of water used in homes, strategies must be developed to reach the existing single-family homes and the 13,400,000 total housing units in the state.

California Water Use Savings Potential

As of January 2014, California had a total housing stock of 13,624,000 dwelling units [4](single-family and multi-family). Of the 7,500,000 single-family homes, more than half were built before the first water-conserving plumbing standards were put into effect in 1980. While some of these homes likely had their fixtures updated at some point, most have not. These existing homes, particularly those built prior to 1980, represent a huge source of potential water savings.

If existing single-family housing (prior to 2011) updated their showerheads and faucets to become CALGreen compliant, over 136 billion gallons of water per year could be saved. This is equivalent to 418,140 acre feet of water, which is equal to 3.8% of the current reservoir capacity in California. An acre

[4] Census Bureau, 2013 Total Housing Units by State

foot of water is the amount of water it takes to cover one acre one foot deep (325,851 gallons), and it can supply two and one half homes with a year's worth of water. If toilets were changed out to low-flow, 1.28 gallons per flush, California could save up to 97 billion gallons of water per year. This is approximately 300,000 acre feet of water, which is 2.7% of California's reservoir capacity.

Another way to conserve water is to reduce the amount of time one has to wait for hot water to appear during showers or baths. Every morning, millions of gallons of water are wasted as homeowners wait for hot water to reach their showers. Studies have shown the average home with a conventional plumbing system uses an extra 10,000 gallons per year waiting for hot water[5]. One way to greatly reduce this waste is through the installation and use of on-demand recirculation systems.

A recirculation system is a pump that moves hot water through the pipe system so that it is readily available when the fixture is turned on. Recirculation systems come in three main varieties, including: *always-on,* where the pump is always on to keep the hot water circulating*; time-controlled*, where the pump is set to run every day at a time you specify that relates to your shower schedule; and *on-demand*, where the homeowner manually activates the pump. On-demand systems use the least amount of energy compared to the time-controlled or always-on systems. On-demand recirculation systems eliminate nearly all water loss from waiting for hot water. The cost to install these systems in existing homes is $500 when installed by a plumber and $250 when you do it yourself.

To understand the overall impact, Table 4 estimates the total water savings available to single-family housing. The savings are calculated by decade as the impacts vary depending on when the homes were built. Overall, the potential savings could be as much as 8.7% of the total reservoir capacity in California, which is approximately 300 billion gallons or 950,000 acre feet of water.

Year Built	Number of SF Units	Fixture Replacement	Toilet Replacement	On Demand System
pre 60s	2,392,460	54,316,019	38,982,743	23,924,600
60s	1,143,459	25,959,950	18,631,521	11,434,590
70s	1,162,924	26,401,864	18,948,684	11,629,240
80s	1,135,153	12,512,792	18,496,183	11,351,530
90s	826,346	9,108,812	1,158,537	8,263,460
00s	889,181	7,951,946	1,246,632	8,891,810
Total gallons (1000s)		136,251,382	97,464,300	75,495,230
Acre feet		418,140	299,107	231,686
% CA reservoir capacity		3.8%	2.7%	2.1%
Total impact as % of CA reservoir capacity				8.7%

Table 4: Savings Impact of Water Conservation Measures

[5] http://www.toolbase.org/PDF/CaseStudies/hot_water_distribution_TN_California_2004_paper.pdf

To understand the savings per dollar spent on each measure, replacement cost was estimated for fixture toilet replacement, and on-demand recirculation system. The costs estimated were for existing housing, including labor for installation. Table 5 outlines these costs and the typical number of units per home needed.

	Cost/unit	Units/home	Total Cost
Showerhead Replacement	$ 50	3	$ 150
Fixture Replacement	$ 50	3	$ 150
Toilet Replacement	$ 250	3	$ 750
On Demand System	$ 500	1	$ 500

Table 5: Retrofit Water Feature Replacement Costs

Table 6 demonstrates the number of gallons saved per dollar spent to upgrade existing homes' showerheads, faucets, toilets, and installing an on-demand recirculation system. Replacing old showerheads is by far the most cost-effective water conservation measure available. Replacing faucets and fixtures are the next most cost-effective feature to replace. If an existing home would replace the showerheads, faucets and fixtures, toilets, and install an on-demand recirculation pump, the cost would be approximately $1,550.

Upgrade Measure	annual savings gallons	upgrade cost	annual gallon savings/$
Replacing 5 gpm showerheads (3)	35,040	$ 150	234
Replace kitchen and lav faucets	22,703	$ 150	151
Replacing 3.5 gpm showerheads (3)	17,520	$ 150	117
Replace 3.6 gpf toilets (3)	16,294	$ 750	22
Install On-demand recirculation pump	10,000	$ 500	20
Replace 1.6 gpf toilets (3)	1,402	$ 750	2

Table 6: Water Savings Cost Effectiveness

The CALGreen water requirements are more cost effective in new construction, since upgrades at new construction costs are substantially less than total replacement costs during a retrofit. The cost increase for a new home to meet the 2010 CALGreen standards is estimated to be $150: $50 per toilet for three toilets. The faucets and fixtures are already standard features in new construction. The on-demand systems are used frequently in new construction, so there is minimal additional cost to achieve these savings. However, the total savings potential for the new code is only applicable to new construction, which accounts for less than 1% of the total housing stock. If California wants to achieve substantial water savings, the existing housing stock must be affected.

Conclusion

Newly constructed, three-bedroom, single-family homes with four occupants use 29,000 gallons less water per year than similar homes constructed in 2005. When compared to homes constructed prior to 1980, which have outdated and inefficient fixtures, new homes can save up to 46,500 gallons per year. Since new construction only adds about one percent to the housing stock each year, and taking into account these home are already water efficient, the focus should be on existing inefficient homes. Since over half of California homes were built prior to 1980, the greatest total savings can be achieved by targeting these homes and retrofitting the existing plumbing fixtures to meet CALGreen.

In order to achieve significant water savings these older, less water-efficient homes must be upgraded with new water-efficient showerheads, fixtures, and toilets to meet CALGreen. Retrofitting existing homes with CALGreen compliant fixtures has been shown to be relatively inexpensive. If all existing homes were retrofitted to CALGreen water standards, California could save 300 billion gallons of water annually, or the equivalent of 8.7% of California's reservoir total capacity, while only costing each home an average of $1,500 or less. With significant water savings and minimal costs, upgrading existing housing represents an extremely cost-effective way of conserving public water supplies.